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(71) Applicant: STARTEC, INC. [US/US]; Suite 240, 6479 Reflections Drive, Dublin, OH 43017 (US).

(72) Inventors: MARSALKA, Joseph, P.; 3504 Avignon Place, Columbus, OH 43221 (US). CULLEN, Donald, L.; 7184 Chadwood Lane, 3B, Columbus, OH 43235 (US). CARTER, Neil, A.; 2111 Silver Street, Granville, OH 43023 (US). JONES, Paul; ul. K. MiArki 6, PL-01-494 Warsaw (PL).

(74) Agent: GILCREST, Roger, A.; Standley & Gilcrest, Suite 500, 555 Metro Place North, Dublin, OH 43017 (US).

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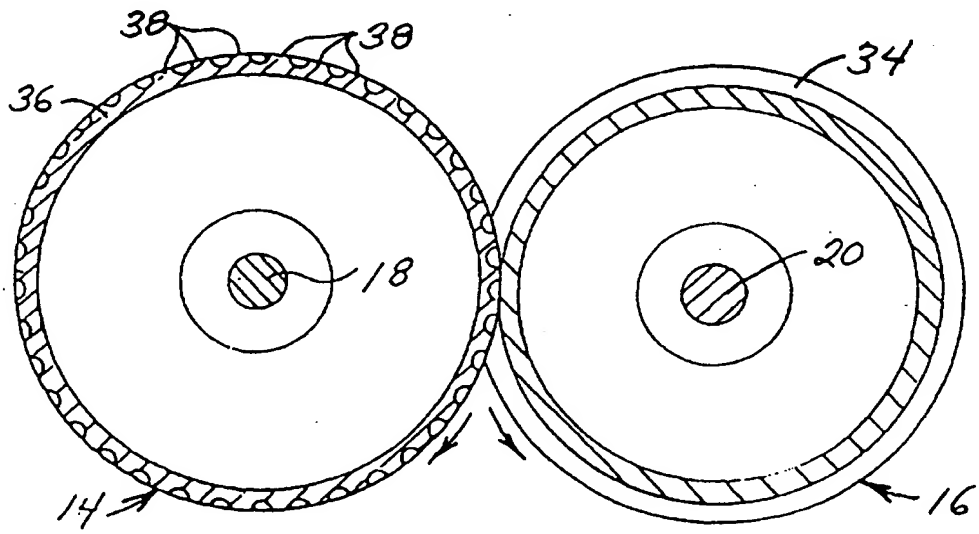
(54) Title: BRIQUET FORMING MACHINE




(57) Abstract

The briquet forming apparatus includes a pair of opposed, generally cylindrical forming roll assemblies (14, 16). Each forming roll assembly (14, 16) has multiple, axially spaced-apart, annularly continuous grooves (34) and multiple, axially spaced-apart, annular rows (36) of forming teeth (38). Each groove (34) has a generally semi-circular groove cross section. Each forming tooth (38) is the cusp of intersecting arcuate surfaces which are essentially concave and semi-circular in directions along the forming roll assembly circumference and essentially convex and semicircular in directions along the forming roll assembly longitudinal axis.

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# BRIQUET FORMING MACHINE

## CROSS-REFERENCES:

None.

## FIELD OF THE INVENTION:

This invention relates generally to apparatus for making fuel briquets and the like from different compatible and/or combustible material mixtures. Such mixtures may be comprised of agricultural products, food products, industry by-products, waste by-products, etc. More particularly the invention concerns an improved briquet forming machine having significantly reduced power and energy requirements for any given product throughput.

## BACKGROUND OF THE INVENTION:

Known fuel briquet-forming machines are typically comprised of one or more pairs of co-operating and counter-rotating rolls that have complementary cup-shaped cavities which form and define the shapes of the fuel briquets that are to be produced, each roll cavity defining generally one half of an individual briquet shape. As the rolls are rotated together, compactible fuel material fed from a supply hopper positioned generally above the rolls is compressed by the mating cup-shaped cavities into the desired briquet shapes. The shapes are subsequently dropped from between the rolls and into a discharge chute or the like positioned generally beneath such rolls.

Several disadvantages are associated with the typical fuel material briqueting machine. For instance, the opposed cooperating rolls or cylinders must be very nearly perfectly registered with respect to each other in their counter-rotation to produce an acceptable product. Also, the prior art apparatus utilizes a relatively small percentage (i.e., 40% to 50%)

of the roll cylindrical surface for cavity space. The remaining land surfaces on the rolls generate excessive frictional forces during fuel material processing thereby requiring increased machine input power to overcome such friction. Further, it is very expensive to form the cup-shape cavities in the co-operating rolls because of the complementary cavity registration or cavity mating requirement.

Another type of briqueting machine technology is utilized for making fuel compacts having cubic or cylindrical shapes formed in part by extrusion. The additional type of machine utilizes offset rotating rolls which rotate relative to an inner cylindrical surface of the machine housing. As the offset rolls are rotated, a pulverized fuel and binder material mixture fed to the housing interior is extruded radially outwardly through multiple dies which are circumferentially positioned about and carried by the machine housing and which each have a square extrusion opening. Cubic briquet shapes subsequently are cut from the square-section extrusions by a scraper blade or the like. As in the case of the counter-rotating roll equipment, extrusion machine power consumption for a given product throughput is very high in comparison to the briqueting apparatus of the present invention.

Thus, apparatus construction simplicity and apparatus operation with minimal internal friction and reduced input power requirement sin comparison to known briqueting equipment are important objectives of the present invention. Other objectives of this invention will become apparent during a careful consideration of the descriptive materials and drawings which follow.

SUMMARY OF THE INVENTION:

The briquet forming apparatus of the present invention is basically comprised of a pair of opposed and generally cylindrical forming roll assemblies that each have their co-operating exterior surfaces configured in a novel manner. In a preferred embodiment of the invention

each forming roll assembly has multiple, axially spaced-apart, annularly continuous grooves, each groove having a generally semi-circular groove cross-section, and also multiple, axially spaced-apart, annularly continuos grooves, each groove having a generally semi-circular groove cross-section, and also multiple, axially spaced-apart annular rows of forming teeth, each forming tooth being the cusp of intersecting arcuate surfaces which are essentially concave and semi-circular in directions along the forming roll circumference and essentially convex and semicircular in directions along the forming roll longitudinal axis, that are alternated with the annular grooves throughout the axial extent of each roll assembly. In the completed apparatus, the grooves of each forming roll assembly cooperate with the forming teeth of the opposed forming roll, and preferably, neither of the opposed forming roll assemblies have cylindrical land surfaces intermediate any adjacent annular groove and alternated forming tooth row.

Also, in addition to the opposed forming roll assemblies with the novel, co-operating exterior surface configurations, the apparatus of the present invention includes a material supply hopper, a briquet discharge chute or conveyor component, and conventional forming roll internal reinforcement, bearing support, and drive shaft elements. Drive gears carried by and keyed to the drive shaft elements are geared to the output shaft of an electric motor of proper operating characteristics.

In an alternate embodiment of the invention the exterior surfaces of the opposed forming roll assemblies may be configured so that all of the annularly continuos groove elements are provided in one of the roll assemblies and are spaced without intermediate cylindrical land surfaces to co-operate with annular rows of teeth provided only in the other of the apparatus roll assemblies and also without intermediate cylindrical land surfaces.

A more detailed description of the invention is developed with respect to the included drawings.

DESCRIPTION OF THE DRAWINGS:

Figure 1 is a perspective view of a preferred embodiment of the briquet forming machine of the present invention;

Figure 2 is a plan view of the apparatus illustrated in Figure 1;

Figure 3 is a schematic sectional view taken along line 3-3 of Figure 2;

Figure 4 is a perspective view of the configuration of a representative fuel briquet formed by the apparatus of Figure 1;

Figure 5 is an elevation and section view of the apparatus opposed forming roll assemblies taken along line 5-5 of Figure 3;

Figure 6 is a schematic elevation and section vie taken along line 6-6 of Figure 5;

Figure 7 is a perspective view of a fragment of one of the forming roll elements illustrated in Figures 2, 5, and 6; and

Figure 8 is a schematic plan view of a portion of an alternate embodiment of the briquet forming machine of the present invention.

DETAILED DESCRIPTION

The forming machine of the present invention, designated generally as 10 in the drawings, is particularly useful for forming fuel briquets form a compactible mixture of fuel materials such as coal or carbon particles, sawdust or other wood particles such as wood chips, paper or paperboard particles, and a binder such as paraffin particles. Representative compactible mixture formulations generally include approximately from 10% to 30% by weight of the combustible binder ingredient and approximately from 70% to 90% by weight of the other particulate constituent or constituents. One particularly important application for the

briquet forming machine of the present invention involves the compaction of particulate fuels derived from pulverizing or shredding combustible municipal solid waste, such waste generally being comprised of paper, plain and corrugated paperboard, polyethylene, and/or polystyrene materials, and mixed with paraffin binder particles. Of course, machine 10 also may be utilized to from briquettes from other materials such as agricultural products and food products. Such pre-mixed particulate materials are normally feed system hopper as illustrated by phantom lines in Figure 1. Also, apparatus 10 generally is mounted above a discharge chute unit or discharge conveyor unit (not illustrated in the drawings) and supported by separate structure.

Referring to Figures 2 and 3, apparatus 10 is essentially comprised of a pair of opposed, generally cylindrical, forming roll elements 14 an 16 supported by their respective drive shafts 18 and 20 which are in tun carried by structural frame 22. A pair of meshing drive gears 24 and 26 are mounted on and keyed to drive shafts elements 18 and 20, respectively. Also typically included in apparatus 10 is a driven sheave element 28 carried by and co-operating with drive shaft element 18, relief compression spring sub-assemblies 30 and 32 which may be adjusted to permit short-term movement of forming roll 16 away from forming roll element 14 in the event an excessively large particle or object of high harness enters the nip of the co-operating forming roll elements, and electric motor, motor driven pulley, and power transmission belt components (not illustrated) for causing rotation of driven sheave element 28 and its connected apparatus components by the electric motor. Suitable sheet metal housings are provided to enclose the various rotating elements of apparatus 10 as a safety measure.

As previously stated, each forming roll element 14, 16 preferably has along its longitudinal axis multiple, spaced-apart, annular forming groove elements 34 and multiple, spaced-apart, annular forming groove elements 34 and multiple, spaced-apart annular rows 36

of forming tooth elements 38, with the forming groove elements 34 being alternated with the annular rows 36 of forming teeth. Also, and at least in part for ease of fabrication, forming grooves 34 each have a substantially semi-circular cross-section throughout their annular extent, and each forming tooth element 38 has a exterior surface configuration that is formed of the intersection of three arcuate, and substantially semi-cylindrical, forming surfaces. The surface configuration of an individual forming tooth element is perhaps best seen in Figure 7 of the drawings. Also, it is preferred that the hollow cylindrical shapes from which the groove and tooth elements 34 and 38 are machined be fabricated by the forging of an AISI 4140 steel that is subsequently stress relieved after the included stiffener plate elements (illustrated in Figure 5) may be fabricated of ASTM A-36 steel.

Figure 5 and 6 of the drawings illustrate the co-operating relationship the preferably exists between the forming groove elements 34 of one of forming rolls 14, 16 and the forming tooth elements 38 of the other such roll, and also the co-operating relationship between he forming tooth elements 38 of the one forming roll and forming groove elements of the other such roll. Also shown in Figure 5, but not identified by reference numerals, are various reinforcement plates, bushings, keys and keyways typically included in apparatus 10 to properly support and connect forming roll elements 14, 16 to their respective one of drive shaft elements 18, 20.

Figure 4 illustrates the shape of the fuel briquette 40 that is produced by processing the pre-mixed particulate mixture referred to above through apparatus 10. Such apparatus, if having forming rolls approximately 27 inches in diameter and approximately 36 inches in length, is capable of producing approximately 32 tons of briquets per hour utilizing a forming roll rotational speed of approximately 40 revolutions per minute to compact and shape fuel particle mixtures comprised of shredded, combustible, solid materials and 20 % to 30%

paraffin binder. Under such conditions apparatus 10 requires input electrical energy at approximately a 30 horsepower power level to attain the throughput productions rate. Such performance represents a 300% increase in output with a requirement of 70% less electrical power in comparison to currently available commercial briqueting machines intended for use in a similar application.

Figure 8 provides details regarding an alternate arrangement of forming roll elements in a briquet forming machine constructed in accordance with the present invention. Rather than alternating forming grooves with rows of forming teeth in each forming roll the alternate embodiment apparatus has the desired rows of forming teeth 36 all provided on one forming roll element 50, and the meshing annular forming groove elements all provided in the co-operating other forming roll element 52. All other elements of apparatus 10 remain essentially the same.

It has been found that because of the differential surface speeds which exist as between each continuous forming groove element 34 of the one forming roll and the engaged forming teeth 38 of the other forming roll element in apparatus 10, any flash present that might tend to connect one formed briquet with an adjacent formed briquet is pulled apart to thereby cause separated briquets to be discharged from between the forming roll elements and into the normally co-operating product discharge chute.

It should be noted that although the terms "semi-circular" and "semi-cylindrical" are used often in the foregoing description to describe that configuration of the arcuate surfaces that define the forming groove elements 34 and the forming tooth element 38, such invention features and their expressions are not utilized in a limiting or restrictive sense since other generally arcuate surface configurations of greater or lesser cross-sectionals "depth" are satisfactory for use in the practice of this invention. Also, cross-sectionals profiles of the

surfaces that define the forming groove elements and forming tooth elements utilized in this briquet forming machine invention may even have included straight-line portions since it is only critical that the forming groove elements have an annular cross-sectional configuration that essentially corresponds to, but is slightly larger than, the cross-sectional configuration of the forming tooth elements that "mesh" with the grooves.

Still other component shapes, sizes and materials may be substituted for the component shapes, sizes, and materials described above to obtain the advantages of this invention and without departing from the claimed scope of the invention:

CLAIMS:

1. In a briquet forming machine, in combination:

a first generally cylindrical forming roll member having multiple annular forming groove elements spaced-apart along the first forming roll member longitudinal axis and separated from each other by multiple annular rows of spaced-apart forming tooth elements;

a second generally cylindrical forming roll member having multiple annular forming groove elements spaced-apart along the second forming roll member longitudinal axis and separated from each other by multiple annular rows of spaced-apart forming tooth elements; and

drive means for causing rotation of said first and second forming roll members in opposite rotational directions with respect to each other,

each annular forming groove element of said first forming roll member engaging and co-operating with a respective one of the annular rows of forming tooth elements of said second forming roll member, and each annular forming groove element of said second forming roll member engaging and co-operating with a respective one of the annular rows of forming tooth elements of said first forming roll member.

2. The briquet forming machine defined by claim 1 wherein said first and second forming roll member annular forming groove elements each have a generally concave arcuate cross-sectional shape, and wherein said first and second forming roll member annular rows of space-apart forming tooth elements each have forming tooth elements that have a generally convex arcuate cross-sectional shape that corresponds to said groove element generally concave arcuate annular cross-sectional shape.

3. The briquet forming machine defined by claim 2 wherein said generally concave and generally convex arcuate cross-sectional shapes are substantially semi-circular cross-sectional shapes.

4. In a briquet forming machine, in combination:

a first generally cylindrical forming roll member having multiple annular forming groove elements positioned adjacent each other along the first forming roll member longitudinal axis;

a second generally cylindrical forming roll member having multiple annular rows of spaced-apart forming tooth elements positioned adjacent each other along the second forming roll member longitudinal axis; and

drive means for causing rotation of said first and second forming roll members in opposite rotational directions with respect to each other,

each annular forming groove element of said first forming roll member engaging and cooperating with a respective one of the annular rows of spaced-apart forming tooth elements of said second forming roll.

5. The briquet forming machine of claim 4 wherein said first forming roll member annular forming groove elements each have a generally concave arcuate cross-sectional shape, and wherein said second forming roll member annular rows of spaced-apart forming tooth elements each have forming tooth elements that have a generally convex arcuate cross-sectional shape that corresponds to said groove element generally concave arcuate cross-sectional shape.

6. The briquet forming machine defined by claim 5 wherein said generally concave and generally convex arcuate cross-sectional shapes are substantially semi-circular cross-sectional shapes.

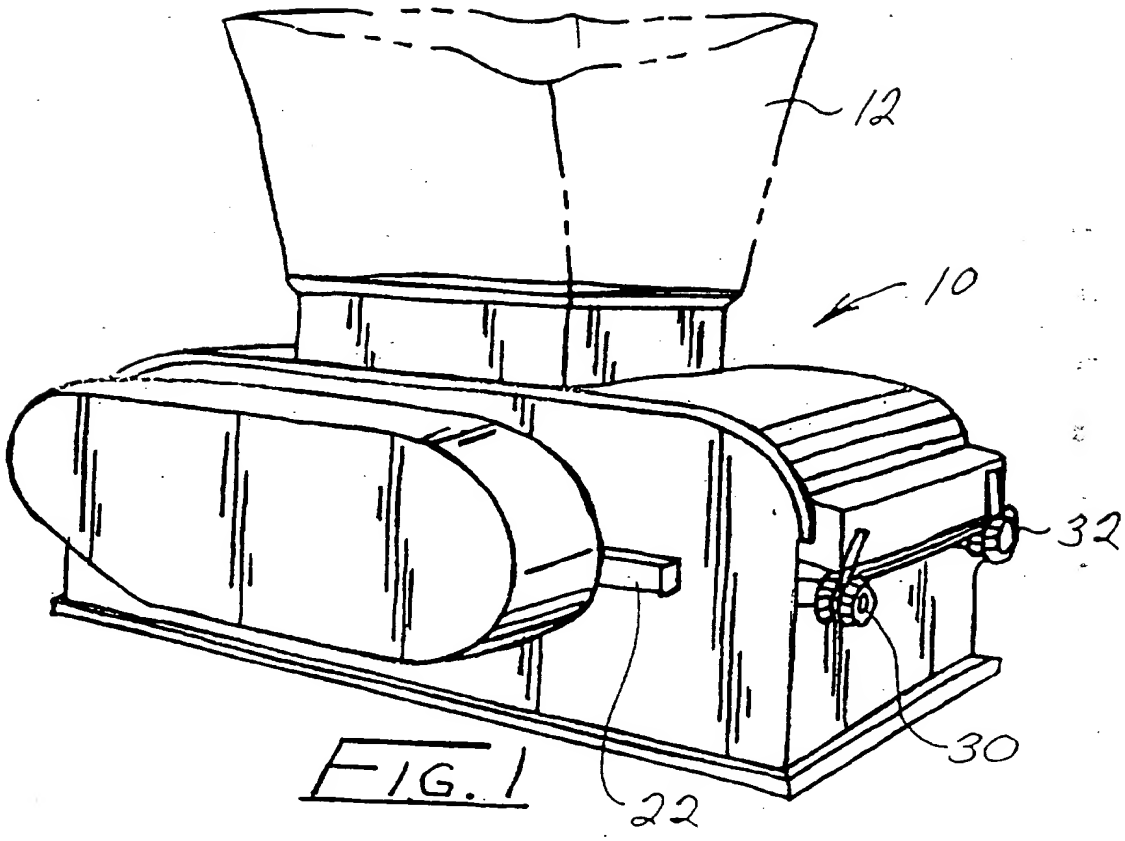


FIG. 1

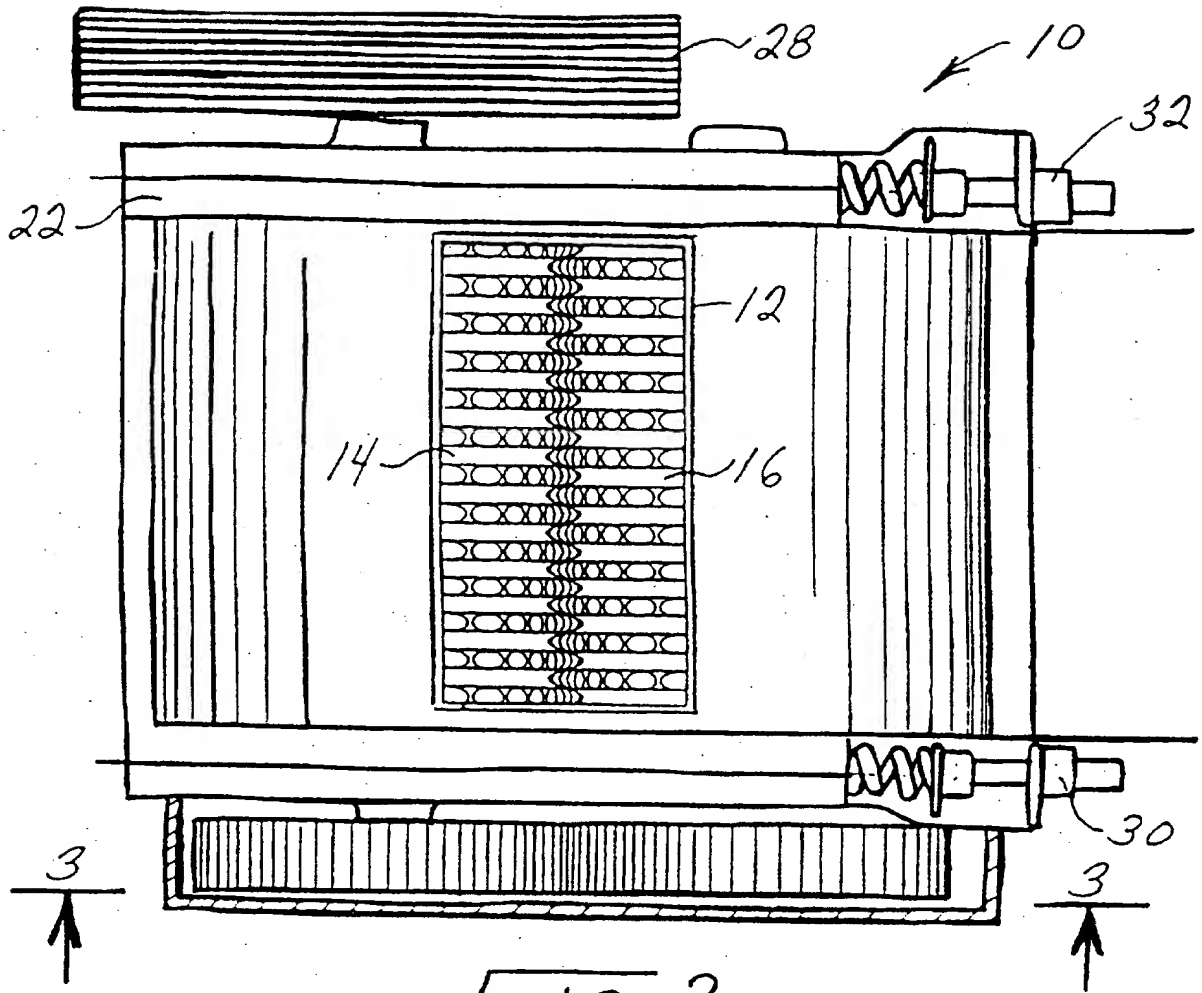


FIG. 2

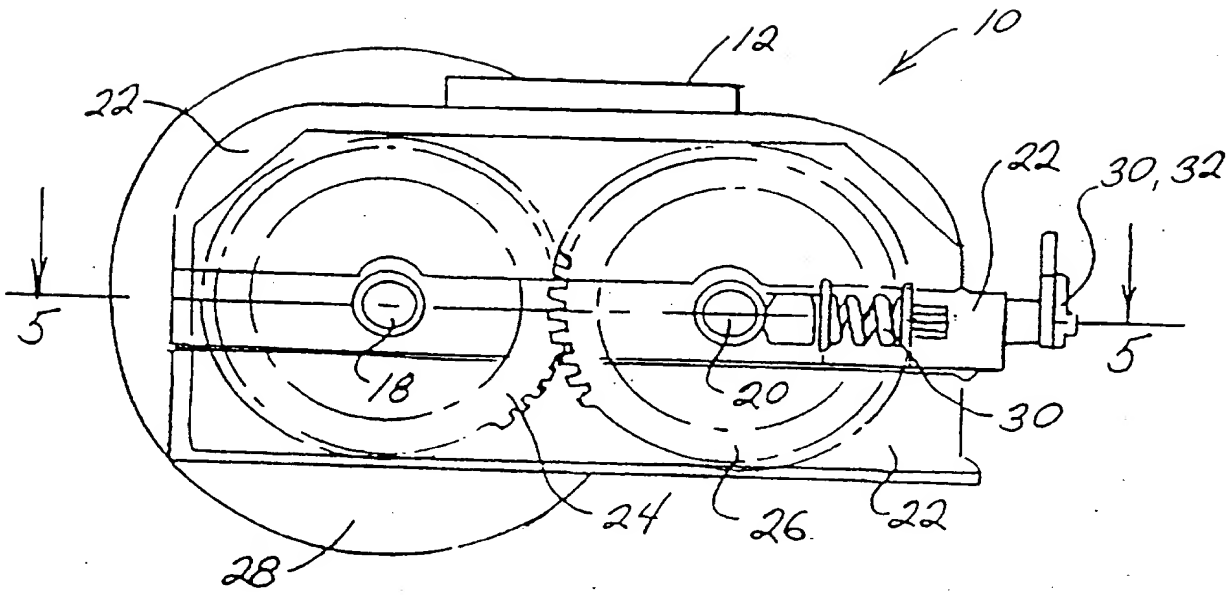


FIG. 3

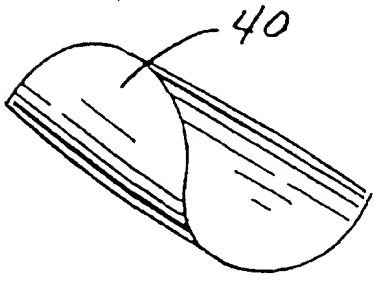


FIG 4

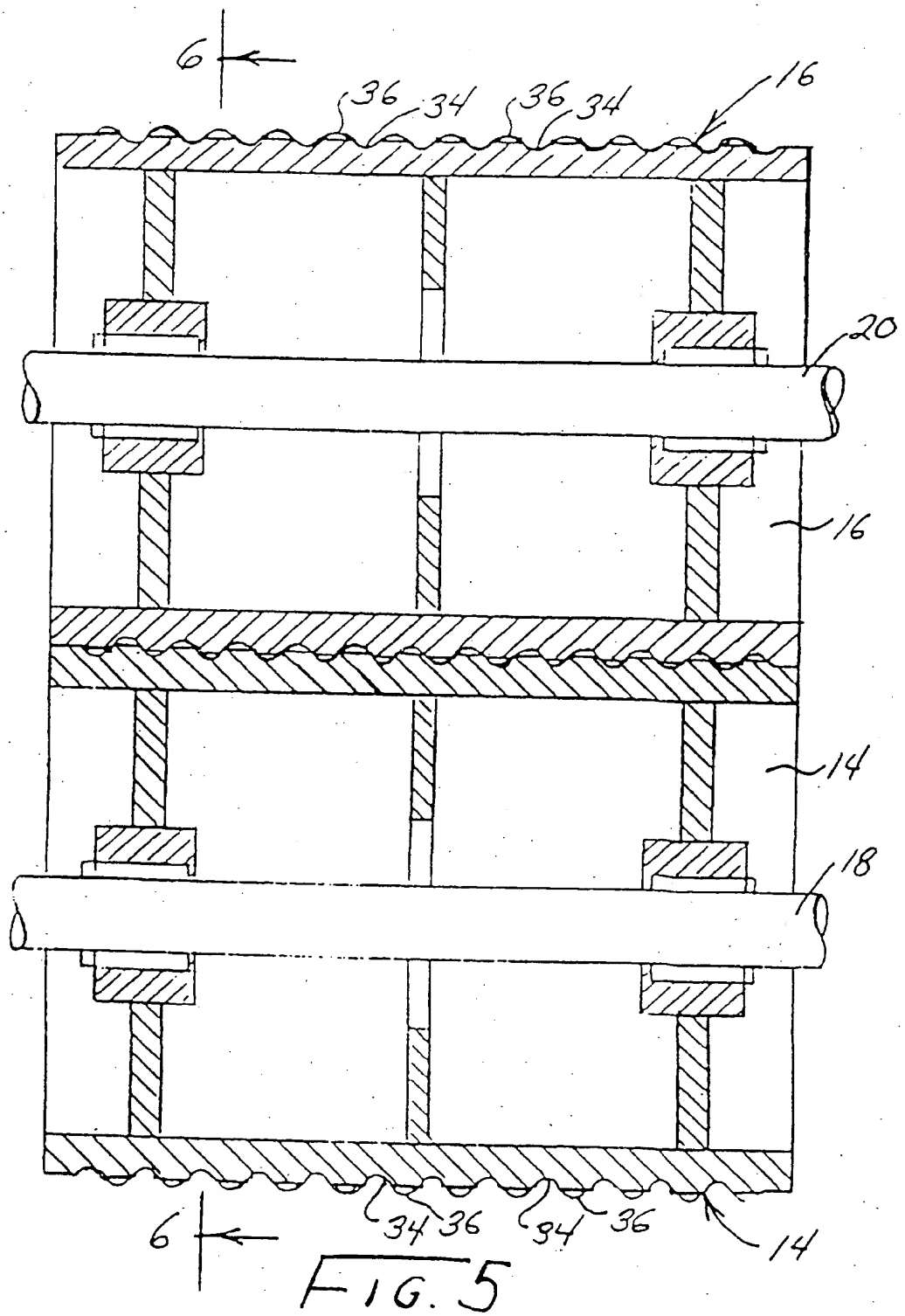


FIG. 5

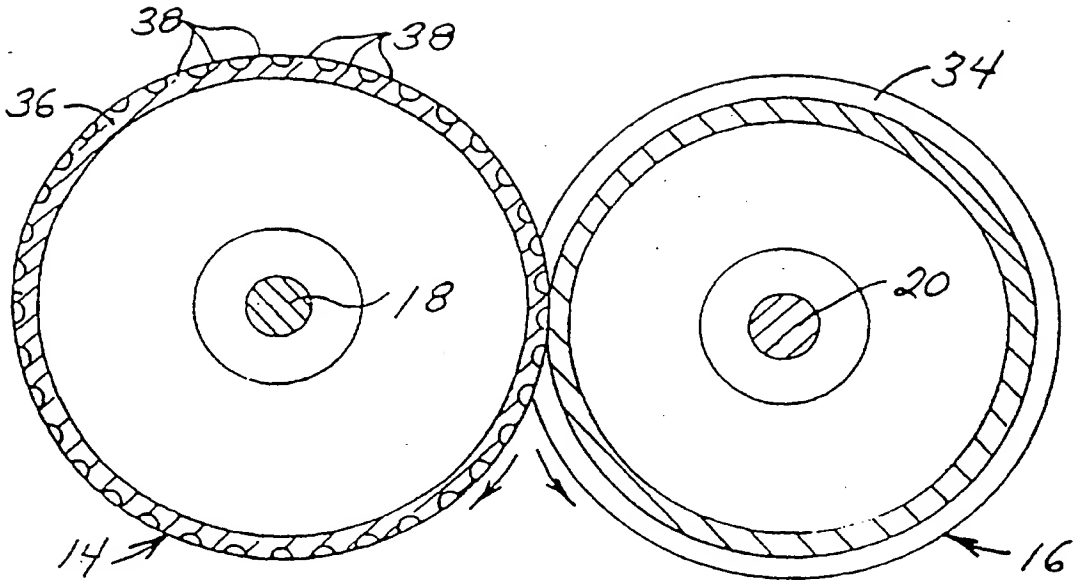


FIG. 6

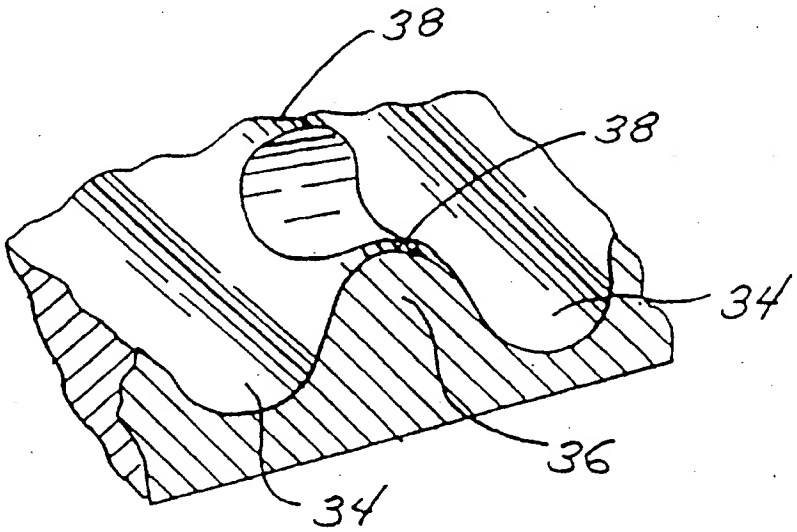


FIG. 7

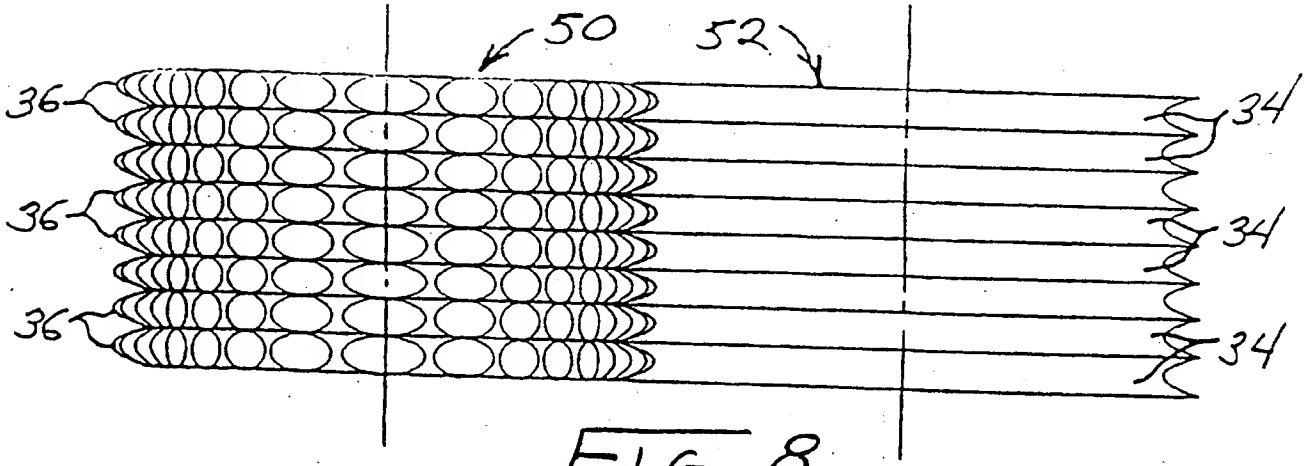


FIG. 8

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/05139

**A. CLASSIFICATION OF SUBJECT MATTER**

IPC(6) :B28B 03/16; B29B 09/00
US CL :264/109, 310; 425/335, 363, Dig. 230
According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

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**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| Y | US 309,117 A (WILLCOX) 09 December 1884, p. 1, lines 100-104, p. 2, lines 1-13, and fig. 2. | 1-6 |
| Y | US 5,073,323 A (MCCARTNEY) 17 December 1991, col. 7, lines 60-67, col. 11, lines 16-43, and fig. 2. | 1-6 |
| Y | US 5,199,269 A (ANDERSSON) 06 April 1993, col. 1, lines 65-68, col. 2, lines 1-12, cols. 3-6, and figs. 2-5. | 1-6 |
| A | US 309,118 A (WILLCOX) 09 December 1884. | |
| A | US 667,050 A (ZWOYER) 29 January 1901. | |
| A | US 676,484 A (ZWOYER) 18 June 1901. | |

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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| A | US 718,043 A (ZWOYER) 06 January 1903. | |

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